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RESISTANCE OF SORGHUM GENOTYPES TO THE RICE WEEVIL, SITOPHILUS ORYZAE (L) (COLEOPTERA CURCULIONIDAE)

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ABSTRACT

Sorghum is the main source of calories and protein in diet of many people's in the regions of Africa and Asia. Despite its multiple importances, Sitophilus oryzae is the most important storage pest of sorghum. This study aimed at evaluated the resistance in five commonly used sorghum varieties along with eleven advanced genotypes against the rice weevil in laboratory. The level of resistance in varieties was clarified based on the dobie index of susceptibility. The result of the study indicated that only two improved varieties, "Lalo and Chemeda" had the least index of susceptibility and grouped as resistance. Weevils reared on this resistsnce varieties produced a few number of progeny, had a long developmental period and, low percentage seed damage and seed weight loss. Genotypes, Acc#8, Acc#17, Acc#19, Acc#2, Acc#5 and Gammachu were grouped as moderately resistant. Percentage seed damage, weight loss and the number of progeny emerged were significantly correlated with susceptibility index, but inversely associated with seed germination. Those resistant varieties, Lalo and Chemmeda, attained the original germination percentage, but the remaining genotypes showed low seed germination. Growing of those resistant varieties, therefore, are cost effective and environmental friendly to reduce grain damage by Sitophilus oryzae

KEYWORDS: Genotpes, Mortality, Progeny, Seed Damage, Sitophilus Oryzae, Susceptibility Index, Resistance & Variety

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Original Article

INTRODUCTION

Sorghum bicolor L. Moench is the fifth important cereal crop in world next to wheat, maize, rice and barley during the past three decades with an annual production of 55.7 million tons (FAOSTAT, 2012). It is the main source of calories and protein in diet of many people's in the regions of Africa and Asia (Waniska and Rooney, 2000). It is the most important cereal crop in Ethiopia used for food, feed, forage and industrial raw material. Moreover, it is considered as crops with less production cost, relatively tolerant to moisture stress and marginal lands. However, the quality and quantity of the grain is deteriorated by a number of storage pests. Among those, Rice weevil, *Sitophilus oryzae* L. (Coleoptera: Curculionidae) is the most important pest of sorghum in the Ethiopia, causing serious losses to many subsistent farmers growing sorghum. (Gwinner, 1998) reported that traditional granaries conditions favor the development of tropical storage insect pests. (Dal Bello et al., 2001) reported that weevil can induce up to 75% of sorghum seed losses when stored in traditional storages). Damaged grains have reduced nutritional values, low percentage germination and reduced weight and market values (Gwinner et al., 1998; Kossou and Bosque-Perez, 1992). Thus, prevention of losses due to storage

insects is of paramount importance. Only few farmers used commercial insecticides due to its high price and less availability (Mendesil *et al.,* 2007). It is generally agreed that insecticides has multiple side effect such as environmental hazards, residual effects, effects on non-target organisms, development of genetic resistance to the limit and the high costs (Cherry et al., 2005). The development of easily available, eco-friendly, and cost effective technologies are the first and foremost priority in the management of insect pests in general and storage pests in particular. Therefore, the present study aims at: (1) screening of naturally resistant sorghum varieties for sitophilus oryzea, (2) assess the numerical impact of sitophilus oryzea infestation on germination rate of sorghum.

MATERIALS AND METHODS

Sitophilus Oryzae Source for Infestation

The rice weevil was collected from granaries and subsequently cultured on sorghum of the susceptible variety Dano in the crop protection laboratory of Bako agriculture research center. About 20 kg of pure and viable seeds was kept in deep freezing at -20 ± 2°C for disinfection. After 5 days, both sex *rice weevil were* transferred to disinfected seed and kept at room temperature and 70% relative humidity, an optimum condition for ovipositor. Two weeks after oviposition, all parent weevils were removed and the progenies of the same age were allowed to infest the seeds.

Genotypes and Technique of Application

Eleven advanced sorghum genotypes were selected from the ongoing regional variety trial based on disease reaction, yield and yield related parameters and Five improved varieties namely Lalo, Dano, Chemeda, Gemmedi, Gemmechu and one local variety were evaluated against *S.oryzae*. The advanced genotypes were originally collected from western Ethiopia and evaluated under different breeding stage. The improved varieties are currently under production in different parts of Ethiopia. Freshly harvested seeds of each variety were used. The moisture content of the seeds was 12 - 13%. About 150 g seeds from each of the sorghum varieties and genotypes were placed in jars allowing ventilation and preventing escape of the weevil. Ten newly emerged adult weevils male/female pairs of both species were introduced into each glass jar. The treatments were arranged in a completely randomized block design with three replications. The experiment was conducted in the laboratory with temperature of 24 - 27°C, relative humidity ranged between 65 - 70% and 12:12 (light: dark) photoperiod. Weevils were allowed to feed, mate and oviposit for 12 days. After oviposit, all parents were removed. The assessments have been done every seven days intervals and extended for the duration of four months. The emerged and dead progeny were removed and counted per jar during each assessment periods.

Loss Assessment

Four month after introduction of sitophilus oryzae, seed weight loss, weight of damaged and undamaged seed were estimated by the count and weigh method (Adams and Saculten, 1978) until the adult emergency stopped. The number and weight of damaged and undamaged seed were determined for each sample of seeds Percentage weight loss was calculated.

$$\text{Weight loss (\%)} = \frac{(Wu \times Nd) - (Wd \times Nu)}{Wu \times (Nd + Nu)} \times 100$$

Where Wu = Weight of undamaged seed, Nu = Number of undamaged Seed

Wd = Weight of damaged seed, and Nd = Number of damaged seed

Index of Susceptibility

The index of susceptibility was calculated as suggested by Dobie (1974). This involves the number of F1 progeny and the length of median developmental time. Index of susceptibility = 100 x [loge (total number of F1 progeny emerged) / (median development time)] The susceptibility index, ranging from 0 to 11, was used to classify the maize varieties; where; 0 - 3 = resistant, 4 - 7 = moderately resistant, 8 - 10 = susceptible and >10 = highly susceptible (Dobie, 1974).

Seed Germination Test

Representative sample of about 100 seeds were taken from infested treatments. Germination test was conducted on medium size of petri dish in the laboratory and was arranged in randomized block design with three replications. Healthy seed germinated percentage is calculated as follows:

$$\text{Percentage of healthy seed germinated} = \frac{Healthy\ number\ of\ seed\ germinated}{\text{Total number of seed in sample}} x100$$

Data Analysis

The collected data were subjected to analysis of variance (ANOVA) using SAS the statistical software (SAS,2008) (version 9.2). Data with regard to percent adult mortality, percent seed damage, and weight loss were subjected to angular-transformation, while the total numbers of progeny emerged data were transformed to log base 10 before subjecting them to ANOVA (Dhliwayo and Pixley, 2003), in order to stabilize the variance.the transformed data were analyzed using one-way analysis of variance. The mean separation, in cases where there were significant differences among treatments, was done using LSD (0.05) to facilitate the comparison of all pairs of treatment means (Montgomery, 2001).

RESULTS

Mortality Rate, F_1 Progeny Emergence and Media Development Period of Sitophilus Oryzae

The analysis of variance revealed highly significant differences ($\leq$0.01) among the sorghum varieties and genotypes on the mortality of Rice Weevil *Sitophilus oryzae* (Table 1). The highest mortality of *Sitophilus oryzae* was recorded in the jar containing variety Lalo (43.4) followed by variety Chemeda (36.5), and genotype Acc#8 (32.4). The minimum mortality of *Sitophilus oryzae* was recorded for acc#14 (4.8) followed by Dano (10.8) and Gemmechu (12.0) varieties (Table 1).

Highly significant variation ($\leq$0.01) was recorded among the varieties and genotypes for the progeny emerged (Table 1). The least percentage of F1 progeny emergence was recorded for Lalo variety followed by Chemmeda. But no significant variation was observed among the remaining test materials (Table 1).

The median developmental time varied significantly (P$\leq$0.05) among the sorghum varieties (Table 1). The maximum number of median developmental time from egg to adult for *sitophilus orazae* was recorded for Lalo (49.5) followed by Chemeda(47) varieties, but the minimum number was recorded for acc#14 (23) and 9 (23.4) (Table 1).

Table 1: The Response of Sorghum Genotypes on Mortality, Number of F1 Progeny Emergency and Media Developmental Period of Sitophilus Oryzae

Varieties and Genotypes	Number of F1 Progeny Emerged	% Sitophilus Oryzae Mortality	Media Developmental Period of Sitophilus Oryzae
Acc#1	110.0+ 2.04d	25.7+1.36e	36.3+1.56dc
Acc#2	98.3+1.99e	22.7+1.35g	35.0+1.54dc
Acc#17	81.0+1.9g	24.9+1.47f	38.8+1.58c
Acc#21	102.3+2.0e	21.0+1.33i	37.0+1.56c
Acc#14	137.5+2.1a	4.5+0.93n	23.0+1.35e
Acc#29	120.0+2.07c	14.3+1.26j	26.0+1.41e
Acc#6	100.0+1.95e	22.8+1.44g	37.0+1.56c
Acc#103	90.0+1.95f	21.4+1.40h	35.5+1.54dc
Acc#19	84.0+1.92g	26.9+1.49d	39.3+ 1.59bc
Acc#9	135.0+2.13ba	5.7+1.03m	23.4+1.36e
Acc#8	66.5+2.11h	32.4+1.49c	39.5+1.59bc
Chemmeda	61.8+1.66h	36.5+1.63aba	47.0+1.66ba
Gemmedi	90.0+2f	22.7+1.4g	38.0+1.57c
Gemmechu	130.0+1.59b	12.0+1.09k	26.4+1.41e
Lalo	39.5+2.08i	43.4+1.69a	49.5+1.69a
Dano	122.0+2.1c	10.8+1.08l	28.3+1.44e
Lsd	5.4	0.23	8.1
Cv	7.3	6.8	10.5
F-test	**	**	

Note: means followed by the same letter within the column are not significantly different at $p < 0.05$. Original (back-transformed) values are presented.

Seed Damage, Weight Loss and Germination Percentage

Highly Significant differences ($P \leq 0.01$) were observed among the sorghum treatments in the loss weight. The least number of seed weight loss were recorded for Lalo (6gm) and Chemeda (6.9gm) followed Acc#8 (11.6gm). Whereas, Acc#14 had the highest record (45.6) of seed weight loss followed by Acc#9 (32.9gm) and variety Gammachu (29.8gm) (Table 2). Also, there is significant variation ($P \leq 0.05$) were observed among the sorghum treatments in percentage of seeds damaged. Low percentage of seeds damaged were recorded for Acc #8 (8.3%) and Lalo (10.67%) followed by Chemeda (21.3). In the contrary, the highest percentage of seeds damaged was recorded for Acc#14 (98.3%), Acc #9 (74%) and Dano (70.7%)(Table 2).

Table 2: Extent of Seed Damage and Grian Weight Loss on 16 Sorghum Genotypes Due to Sitophilus Oryzae

Genotypes	% Seed Damage	% Grain Wheight Loss
Acc#1	38b+1.57cd	24.4+1.38c-d
Acc#2	40.3+1.6b-d	20.7+1.31b-e
Acc#17	37b+1.56cd	14+1.14b-e
Acc#21	45+1.65a-d	24+1.38b-d
Acc#14	98.3+1.99a	45.6+1.65a
Acc#29	60.3+1.77a-c	27.3+1.43a-c
Acc#6	38.6+1.57b-d	18.7+1.27b-e
Acc#103	48+1.68b-d	22.4+1.35b-d
Acc#19	39.6+1.59b-d	17.8+1.25b-e
Acc#9	74+1.86ab	32.9+1.51ab
Acc#8	8.3+1.50cd	11.6+1.06c-e
Chemmeda	21.3+1.32b-d	6.9+0.83de
Table 2: Contd.,		
Gemmedi	40.3+1.6b-d	23.6+1.37b-d

Gammachu	61+1.78a-c	29.8+1.47a-c
Lalo	10.67+1.02cd	6+0.77ed
Dano	70.67+1.84ab	28.9+1.46a-c
Lsd	54.8	19.8
cv	16.6	18.6
F-test	*	**

Note: Means followed by the same letter within the column are not significantly different at p< 0.05. original values were used for the analysis. (back-transformed) values are presented here; however, angular transformed

Seed Germination and Susceptibility Index

The index of susceptibility ranged from 2.8 for variety Lalo and 9.3 for acc#14 (Figure 1). The result of study revealed that out of the seventeen test materials (5 varieties and 11 genotypes) evaluated for their resistance to *S. oryzae*, only two varieties, namely Lalo and Chemeda were rated as resistant according to Dobie (1974) rating scale. However, Acc#1, Acc#2, Acc#6, Acc#8, Acc#14, Acc#17, Acc#19, Acc#21 and Acc#103 genotypes and one variety, namely Gemmedi were categorized under moderately resistant and, Acc#9, Acc#14 and varieties, Gemmechu and Dano were susceptible to weevil attack (Figure 1).

The damage due to *S. oryzae* infestation affected the germination of sorghum varieties and genotypes. The result of study revealed that significantly the highest percentage of seed germination was recorded for variety Lalo (69.5 %) followed by Gemmedi (65 %).While, Percentage of germination was minimum in genotype, acc#9 (22%) followed by variety Gemmechu (25.5%) (Figure 2)

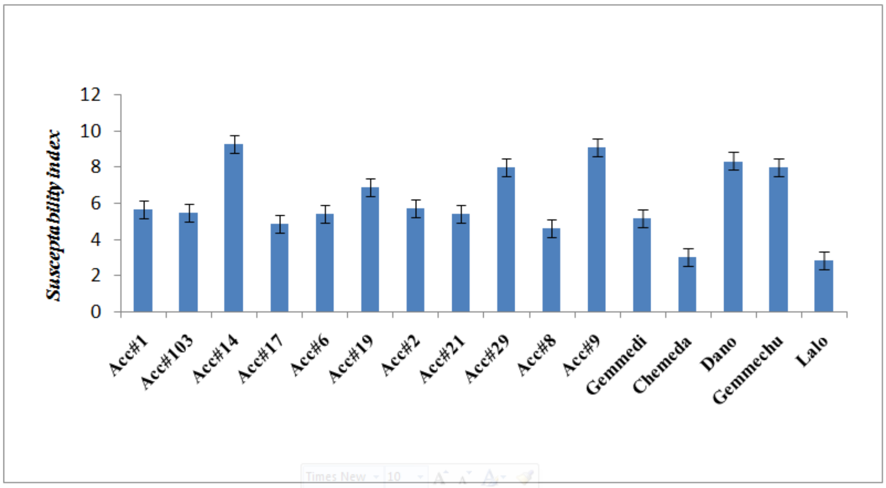

Figure 1: Susceptability Index of Sorgum Genotypes (1-11scale), where; 1-3 =Resistant, 4 -7=Moderate Resistance, 8-11= Susceptable, and >11= Very S Susceptableaccording to Dobie, 1974 Classification

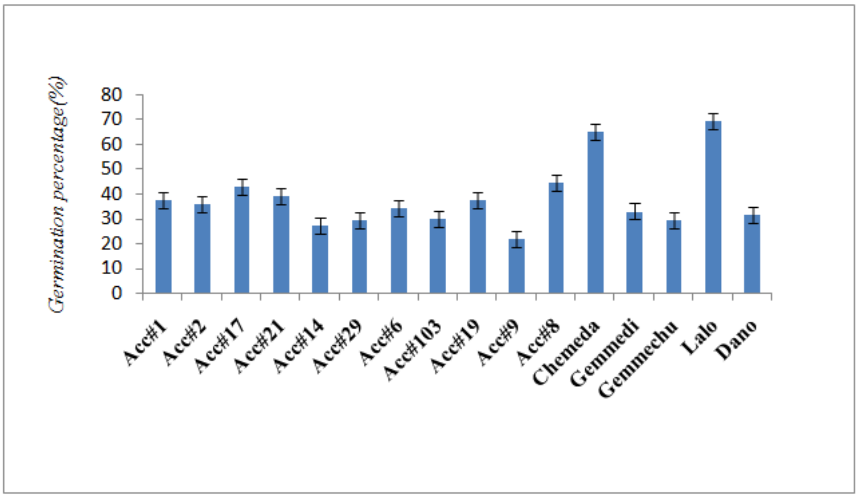

Figure 2: Seed Germination Test for 16 Sorghum Treatments (5 Varieties and 11 Advanced Genotypes) Infested by Sitophilus Oryzae

Analysis of Correlation Coefficient

The simple linear association between variables like number of seed germination, F1 progeny emerged, weight loss, seed damage and, susceptibility index were determined for 16 sorghum test materials. The susceptibility index was positively correlated to the important parameters such as the number of F1 progeny emergence, percentage of seed damage and percentage seed weight loss. With an increasing in susceptibility index, there was an increase and highly significant percentage of grain weight loss ($r = 0.97$, $P \leq 0.01$), percentage of seed damage ($r = 0.96$, $P \leq 0.01$) and number of F1 progeny emerged ($R^2 = 0.95$, $P \leq 0.01$) (Figure 3, 4 and 7). However, the susceptibility index was negatively and significantly associated with percentage of seed germination (R^2 =- 0.97, $P \leq 0.01$) (Figure 6) and not significantly associated with *Sitophilus oryzae* mortality (R^2 =- 0.46, $P \leq 0.05$) (Figure 5).

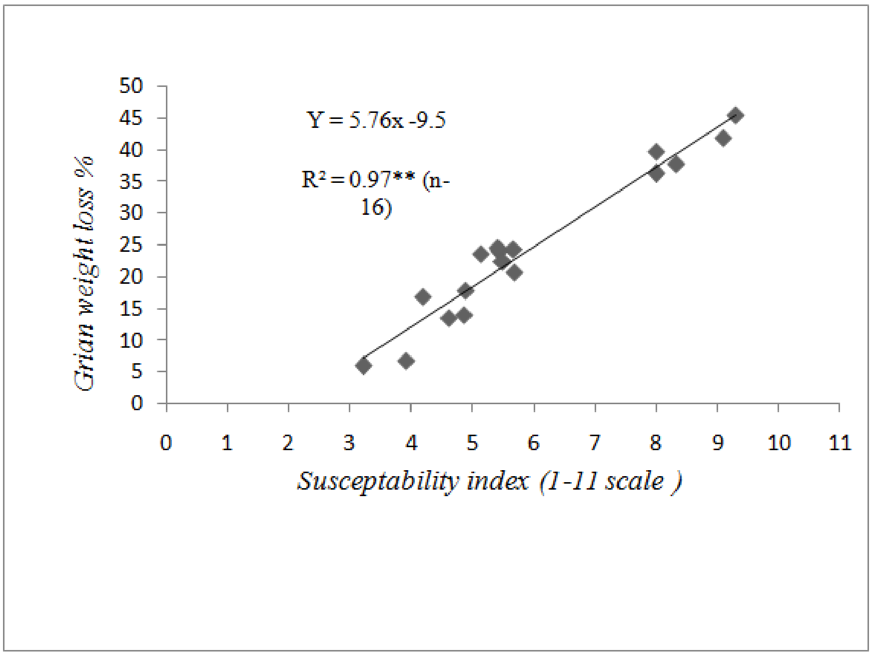

Figure 3

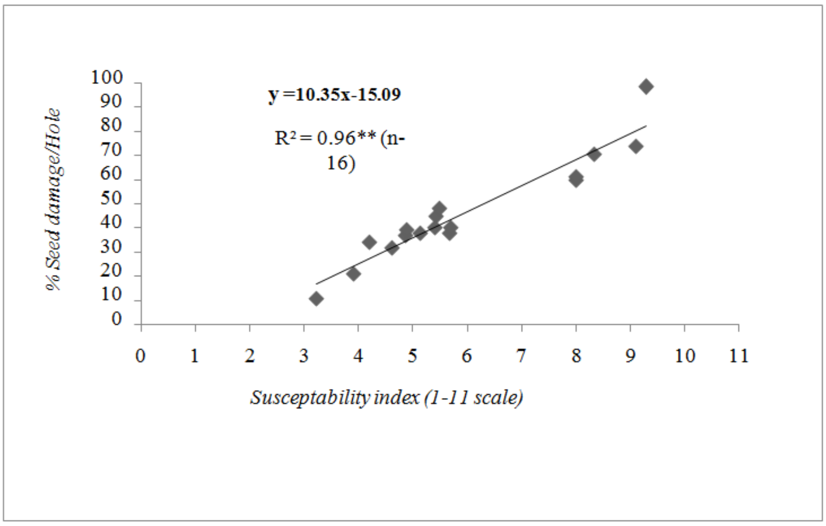

Figure 4: Correlation between Susceptability Index and Seed Damage (Open Dots) for 16 Sorghum Genotypes Infested with Sitophilus Oryzae (Highly Significant by Student's Test at 1% Probabily)

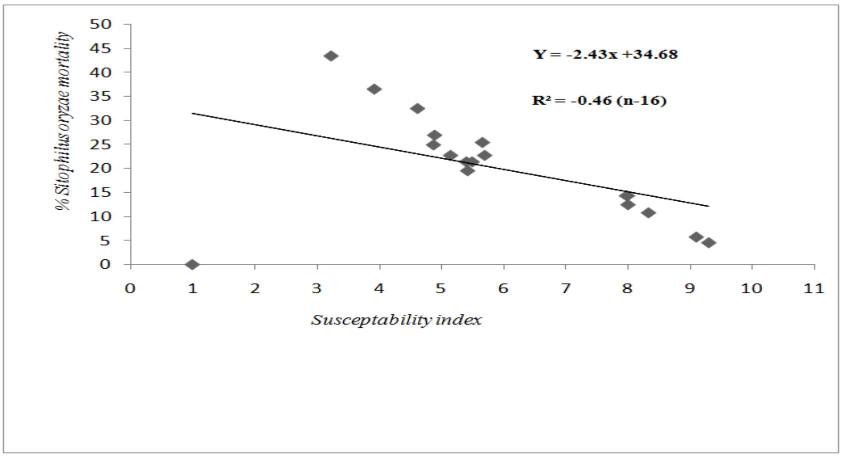

Figure 5: Correlation between Susceptability Index and Sitophilus Oryzae Mortality on 16 Sorghum Genotypes (Not Significant by Student's Test at 5% Probability)

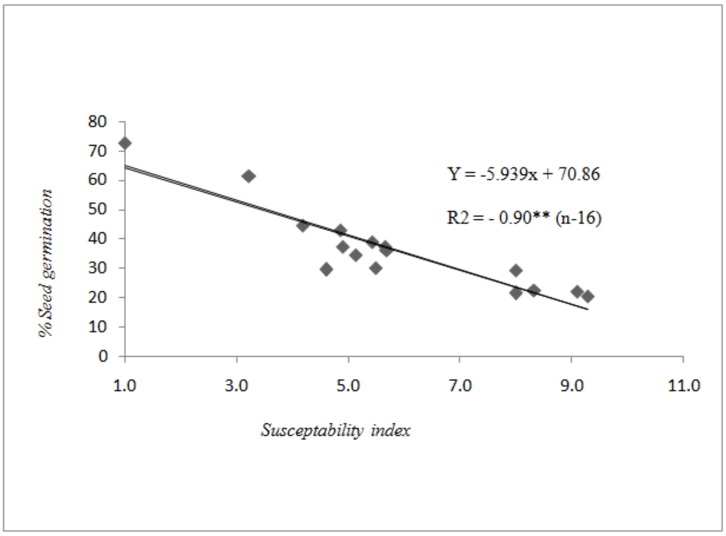

Figure 6

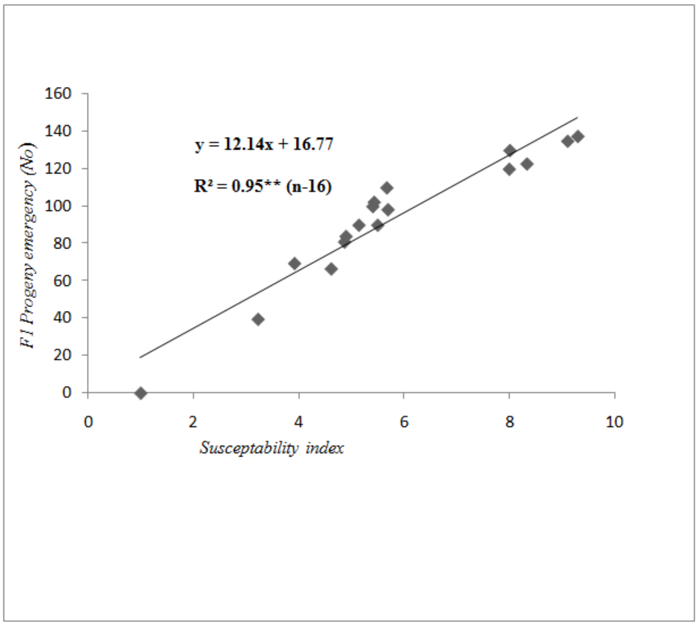

Figure 7: Correlation between Susceptability Index and No. of F1 Progeny Emerged for 16 Sorghum Genotypes (Highly Significant by Student's Test at 1% Probability)

DISCUSSIONS

The result of the present study portrayed variations in the genetic potential of some released sorghum varieties and advanced genotypes for weevil resistance. In this experiment, we found considerable variation among the varieties and genotypes with regard to F_1 progeny emergence, the period required for development of weevil from egg to adult, susceptibility index, mortality rate of *S.oryzae*, seed damage and seed weight loss. These variations in the differential susceptibility of the sorghum varieties and genotypes show the innate capacity of a particular variety to resist *sitophilus oryzae* attack. Several factors are responsible for differences in genetic variation of sorghum varieties to resist or tolerate insect attack through their influence on fecundity and development of *sitophilous* spp (Shazali, 1987; Adentuji, 1988). These factors includes presence of toxic alkaloids or amino acids, insect feeding deterrents, pericap surface texture, enzyme inhibitors, grain hardness, grain temperature and moisture content. These factors acting alone or in combination are responsible for the varying levels of resistance to certain species of storage insect pests (Baker, 1976; Wongo and Pedersen, 1990; Ramputh *et al.,* 1999; Chandrashekar and Satyanarayana, 2006). Bamaiyi *et al.* (2007). Weevils are usually multiplied rapidly on susceptible varieties and genotypes without strong defense from the host and this would be accompanied by massive consumption of grains. *Sitophilus oryzae* required less developmental time on the susceptible genotype such as acc#14 (23 days) and acc#9 (23.4 days), but longer developmental time was elapsed on the resistant varieties such as Lalo (49.5 days) and Chemeda (47days). Therefore, the susceptible sorghum genotype, acc#14 (23 days), had approximately 24 day shorter developmental period for the number of F1 emergence than the resistant varieties, Lalo and Chemeda. The maximum number of F1 progeny were emerged on acc#14 (137.5 No of F1 progeny) followed by acc#9 (135 No of F1 progeny) while, the minimum number F1 progeny were emerged on the variety, Lalo (39.5 F1 progeny) followed by Chemmeda (61.8 F1 progeny). According to Horber (1988), the susceptibility index is based on the assumption that the higher F_1 progeny and the shorter the duration of the development, the more susceptible the varieties would be. Similarly, Abraham (1991) reported that the extent of damage during storage depends upon the number of emerging adults during each generation and the duration of each life cycle and seeds permitting more rapid and higher

levels of adult emergence would be more seriously damaged. In the present study, we found an inverse relationship between the susceptibility index and percent mortality and seed germination. However, the numbers of F_1 progeny emerged, percent seed damage and seed weight loss was positively related with the susceptibility index. It can be recapitulated that if resistant sorghum varieties extend the developmental period of *sitophilus oryzae,* the post harvest loss incurred during storage of farm produce will be minimized to a large extent. Storage pests consume the endosperm and embryo thereby causing a noticeable reduction in seed viability. Of the sixteen varieties infested in the laboratory, only the resistant variety, Lalo and Chemmeda, attained the original germination percentage while the rest suffered significant reduction in viability.

CONCLUSIONS

Out of the sixteen sorghum genotypes tested against *S.*oryzae, only two varieties 'Lalo and Chemeda found to be resistant. Whereas, Acc#2, Acc#6 Acc#8, Acc#17, Acc#19, Gemmechu and one local variety were regarded as moderately resistant. Resistant varieties, therefore, can be utilized as an environmental friendly way to reduce damage by *S.* zeamais under traditional storage conditions and can also be reduce the cost of weevil's management. Thus, the materials were identified in this study may also used as a source of resistance in breeding programs in the future to diversify the basis of resistance to other pest.

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